Brain enabled mechanized speech synthesizer using Brain Mobile Interface

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Abstract: **Communication is easily evoked when the necessity to carry out the thoughts and vision arises. As the communication technology developed it cultivated the threats of information security, on the other hand physically challenged people have no possibility to communicate freely hence the urge for development in the field of communication is necessary in present scenario. Aim of this work is to propose a system that improves the present communication system. Here we had put forward the concept of Brain Mobile Interface (BMI) from the basis of Brain Computer Interface (BCI). BMI serves as a device to translate human thoughts about speech without the need of physical movement. Wireless EEG headsets are used to acquire the speech signals directly from the brain and after signal processing it is given to the mobile which consist of inbuilt speller application. With the help of speller application the message to be conveyed is acquired as text which is then converted into speech by means of text to speech converter.**

Keywords: Brain Mobile Interface (BMI), Brain Computer Interface (BCI), Signal processing, Speller application.

I. INTRODUCTION

Until recently, reading human mind is just a science fiction. However the development in technology broke the science fiction and brought the reality into play. Neural signals acquired from the brain based upon brain activity interact with influence or change their environment. Brain-mobile interfaces (BMIs) [6] are systems that permit to decode real time digital signals from electrical activities of the brain by means of manipulating gadgets. BMI does not depend upon cessation of physical movements, hence capable of providing superior communication and control and also can be used by physically challenged people. Researches based upon brain computer interface has greater boon in recent years. Until now, EEG based systems have been utilized to restrain mouse for personnel computer [2], natural speller [1], [3], online browsers [4],[5] etc. In this paper we proposed a system that serves as a brain mobile interface where a smart phone is directly interfaced with human brain via wireless EEG headset. These are obtained by measuring the electric potential difference produced by brain activity. The electroencephalography [6] (EEG) is footage of electrical bustle occurring in brain by placing electrodes on the human scalp. Small electrodes are placed on the scalp to measure the electric fields resulting from the changing flow of electric current athwart the membrane during the period in which neurons process information. The difference in potential between different electrodes are then amplified and recorded as EEG. Event Related Potential (ERP) has been exploited to read the brain's complex physiological process like selecting the appropriate stimuli and ignoring other stimulus, decision making on choosing the stimuli, speech reorganization and gain knowledge about new things.

II. MATERIALS AND METHODS

This section will provide detailed description about the hardware & software being used, electrode posing and P300 Event Related Potential.

A. Hardware & Software

Hardware section consists of a smart phone with inbuilt speller application and a wireless EEG headset capable of interfacing with the smart phone. Even though the possibility of Human Machine Interface (HMI) has been identified years ago it was meant only for the purpose of research and medical analysis due to the requirement of complex wiring to fix electrodes on scalp as well as water or gel must be applied on the electrode to make it conductive because of these reasons HMI was not feasible for practical application. To overcome this problem wireless EEG headsets with dry electrodes have invented in recent years which is free from wires and does not require gel or water for making electrodes conductive. B-Alert X10 is one such device. It is an efficient solution for mobile EEG applications. The lightweight headset remains comfortable for high quality recordings.

Product features and specifications are as follows

- 9 channels of medical-grade EEG, plus 1 optional channel for ECG, EMG, or EOG (10 Channels @ 256Hz)
- Bluetooth wireless signal transmission up to 10 meters

- compatible with MatLab, EEGLab, and BCI2000, Open ViBE
- sampling rate: 256 samples/second
- Bandpass characteristics: 0.1Hz HPF, 100Hz 5th order LPF
- RF band: 2.4 to 2.48 GHz
- Sensor sites Fz, F3, F4, Cz, C3, C4, POz, P3, P4

Fig. 1: B-Alert X10

On the other hand the software section consists of openViBE, which is a software for real-time neuroscience. It can be used to acquire, filter, process, classify and visualize brain signals in real time. OpenViBE can support speller application and can be installed on smart phones. It is free and open source software that works on Windows and Linux operating systems.

B. Electrode Posing

Posing of electrodes in brain is done using 10-20 international system. Figure 2 represents the electrode posing positions for acquiring speech signal.

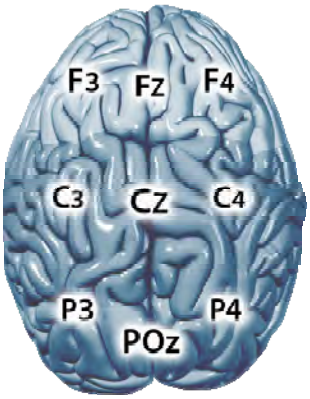

Fig. 2: position of electrodes

C. P300 Event Related Potential

P300 ERP is a positive deflection (2 to 5v) potential. It has latency around 300 to 600 ms starting from the onset. The electrode positioning of P300 ERP should lie in Fz, Cz, Pz regions graphical representation of which is shown in figure 3. The openViBE software

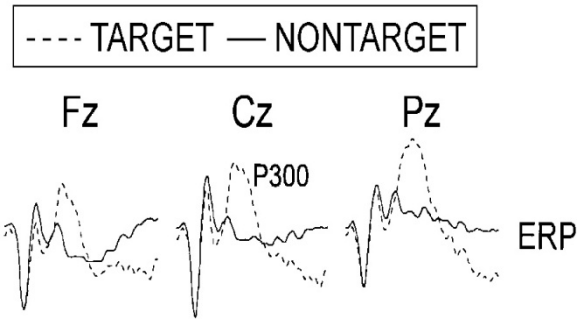

Fig. 3: graphical analysis of P300 ERP

Consists of toolbox to perform the necessary actions to remove the noise from the EEG signal to acquire desired ERP. At first the EEG signal is Band Pass Filtered then required ERP is obtained after averaging the segments of single trial ERP.

III. METHODOLOGY

Figure 4 shows the architecture of the proposed system. The wireless EEG headset consists of Electrodes that are used to acquire the neural signals responsible for speech and it consist of RF system to convert the obtained neural signals into RF signals so that it can be received by the mobile. The mobile consists of Open ViBE software and the speller application. The Open Vibe software at first Pre-process the received signal which converts the received signal into desirable format and then feature

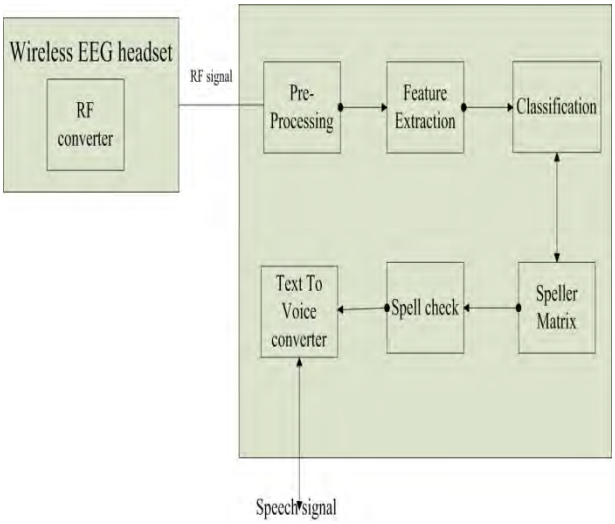

Fig. 4: General architecture

extraction is carried out which extracts only the necessary information i.e, when the subject imagines the action of speech not only the neurons responsible for the speech production will fire but also the neuron that are responsible for certain actions like movement of hand or leg or some other thought will fire simultaneously now our task is to separate the correct event related potential from the preprocessed signal

A. Separation of P300 ERP from non-P300 ERP

The probability of choosing the correct event and the speed decreases due to the presence of non-P300 event related potential which gets hold on during the process of extracting P300 event related potential. The non P300 ERP can be removed by means of constrained independent component analysis (cICA) which can extract only the appropriate component by assimilating the information obtained former. Figure 5 represents the block of cICA where the acquired signal is band pass filtered and given to cICA containing prior knowledge about the P300 ERP as a result of which appropriate P300 component is obtained. Figure 6 shows both target and non target signals and figure 7 shows the extracted independent component from the target data.

B. classification and the speller application

The feature extracted signals consist of only necessary information. The signals are to be finally classified in order relay it to the speller application. The speller application is inbuilt in the smart phone itself that consist of a 6 x 6 matrix containing

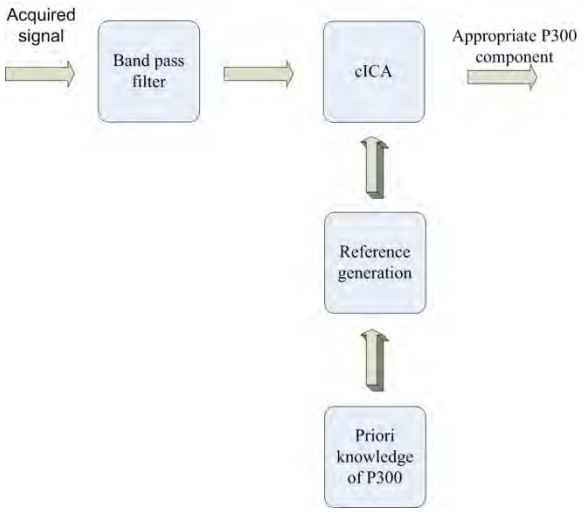

Fig. 5: block diagram of cICA

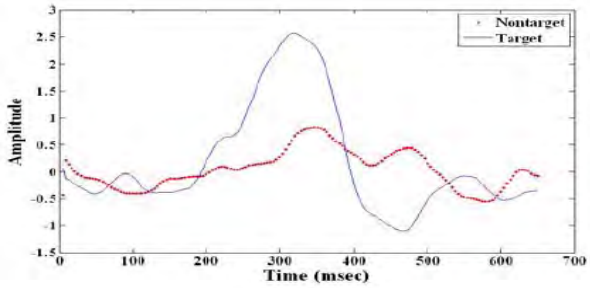

Fig. 6: P300 and non P300 signal

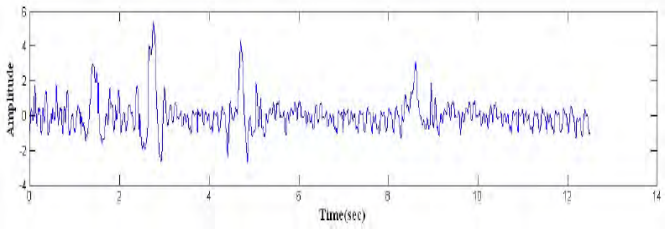

Fig. 7: Extracted independent component from the target data

Alphabet A to z and number 0 to 9. The user is asked to concentrate on the 6 x 6 matrix which in turn stimulates the neuron to fire based upon the users concentration on the screen the message to the be conveyed will get typed. After acquiring the entire message automatic spell check is set on to make the message error free. Finally the obtained text is converted into speech by means of text to speech converter.

IV. RESULT AND DISCUSSION

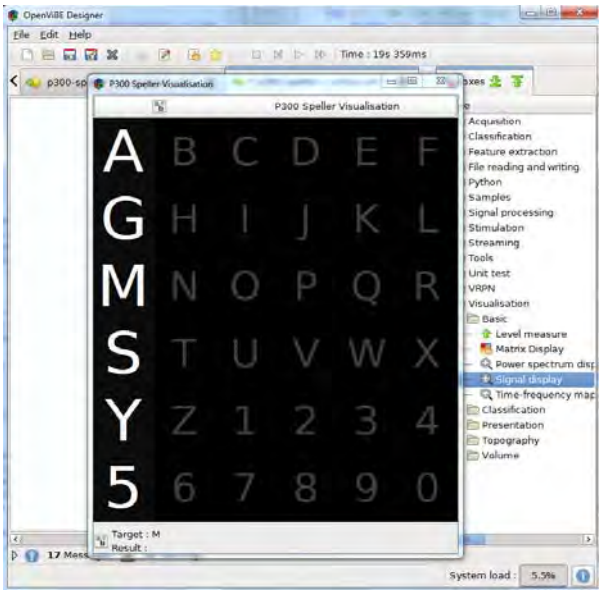

Fig. 8: Speller matrix

Figure 8 shows the speller matrix with alphabets and numerals in which the user has to concentrate in order to make the selection. It flickers randomly in order to help the user choose the correct word.

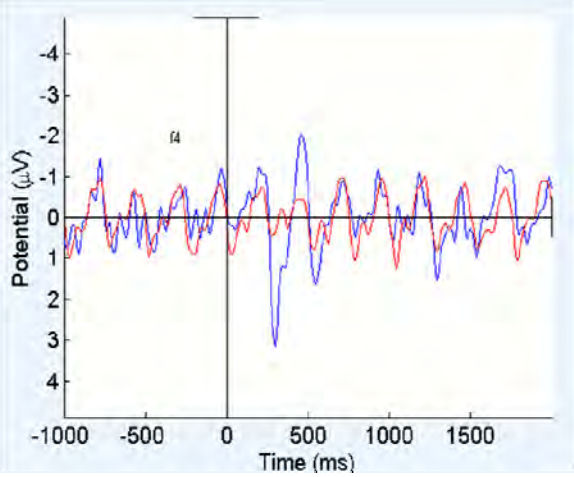

Fig. 9: EEG pattern of target and non-target waveform for single channel.

Figure 9 shows the target and non-target stimuli of single channel EEG waveform it can be noted that the potential raises at around 300 to 350 ms i.e the response to the target will be accurate during this time period and that is why it is termed as P300 Event Related Potential (P300 ERP).

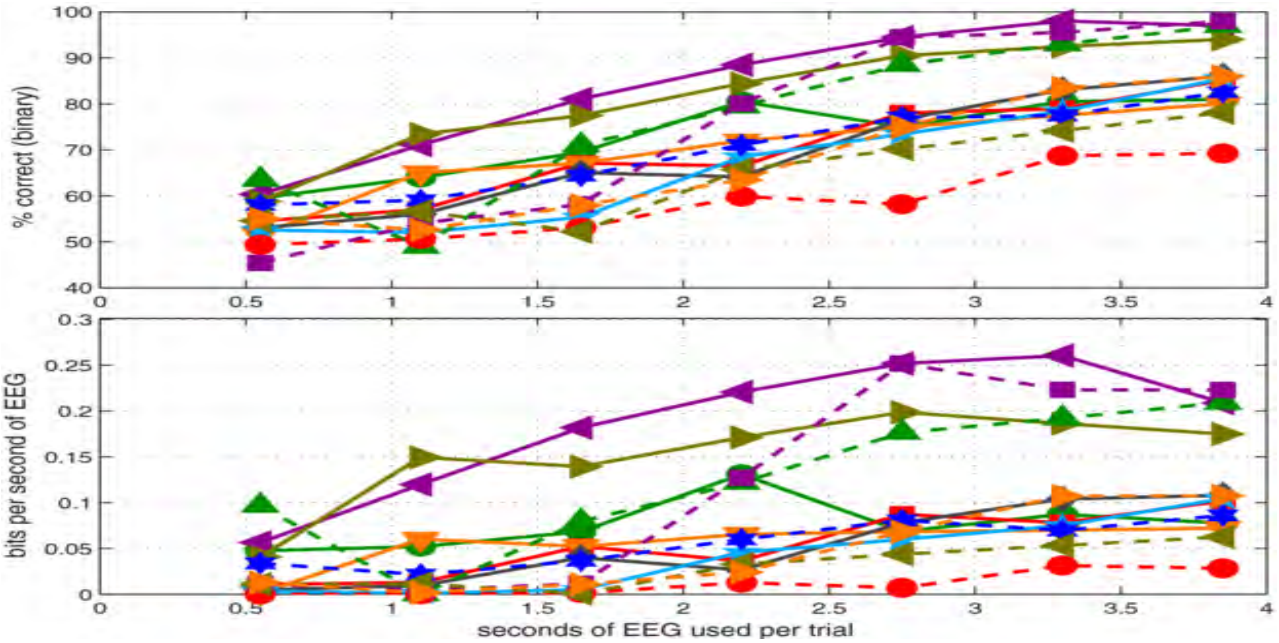

Fig. 10: plot between time duration and bits per second of EEG signal.

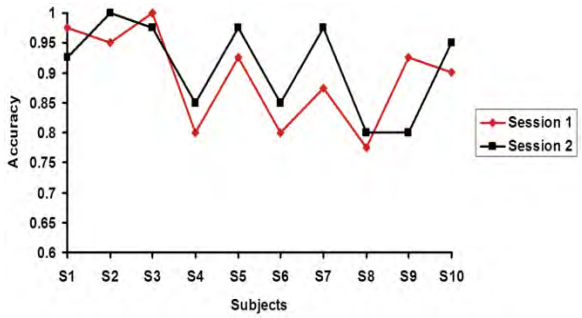

Fig. 11: Accuracy plot

Two different sessions were conducted to study the performance analysis of the system. In each session 10 different subjects were chosen. Each subject was provided with a word as target and are asked to speak out that word silently by imagining. Finally their performance is analyzed and a plot is drawn, Figure 11 shows the accuracy plot of different subjects for two different sessions. The plot infers that the accuracy changes from subject to subject but still it had never fallen to minimum level. Hence the overall performance of the system is good. Figure 10 shows the plot between number of bits per second of EEG data to time duration (number of seconds) of EEG data per trial.

VI. CONCLUSION

In this paper we had put forward the emerging brain mobile interfacing technology for the purpose of real time silent speech production that improves the communication by making physically challenged people to convey their thoughts freely and also it improves the information security. It will serve it advantage in the field of education, military, medicine and so on. The results of brain mobile interfacing device were discussed and accuracy graph is plotted for 2 different sessions. It is realized that the BMI device is more efficient. In future different applications can be developed in different fields.

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